

Ocean Dynamics

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LONG-TERM GOALS

To gain a more complete understanding of ocean dynamical processes, particularly at fine-scale, through intercomparison of high, mid- and low-latitude observations, both near the sea surface, in the main thermocline, and near the sea floor.

OBJECTIVES

To identify the phenomena involved in the cascade of energy from mesoscales to turbulent scales. To quantify the relationship between fine-scale background conditions and the occurrence of microscale breaking.

APPROACH

Progress is effected through a steady-state cycle of instrument development, field observation and data analysis. The primary instruments employed include Doppler sonar and profiling CTD's. Generically, our instruments produce information which is quasi-continuous in space and time. Measurements typically span two decades in the wavenumber domain. This broad band space-time coverage enables the investigation of multi-scale interactions.

WORK COMPLETED

Graduate student Chris Halle is completing an extensive study of Arctic internal waves and eddies. Work is based on data from the ONR CEAREX (1989) and SIMI (1993-4) experiments. Observations are from a 161 kHz coded pulse Doppler sonar (CEAREX) and a RDI 150 kHz narrowband ADCP (SIMI).

RESULTS

In viewing the four-month SIMI record, we anticipated a strong seasonal cycle. The hypothesis was that, following a summer of open water, internal wave energy levels would be high. Over the winter, under the growing ice cover, wave energy levels were expected to decay. In fact, the reverse pattern was found. Initial wave energy levels in the central Beaufort Sea were low. Later in winter, three distinct generation events increased the standing energy levels significantly. While the SIMI camp was in a region of rough topography at the time, the observation clearly indicated that energy was propagating downward from the sea surface.

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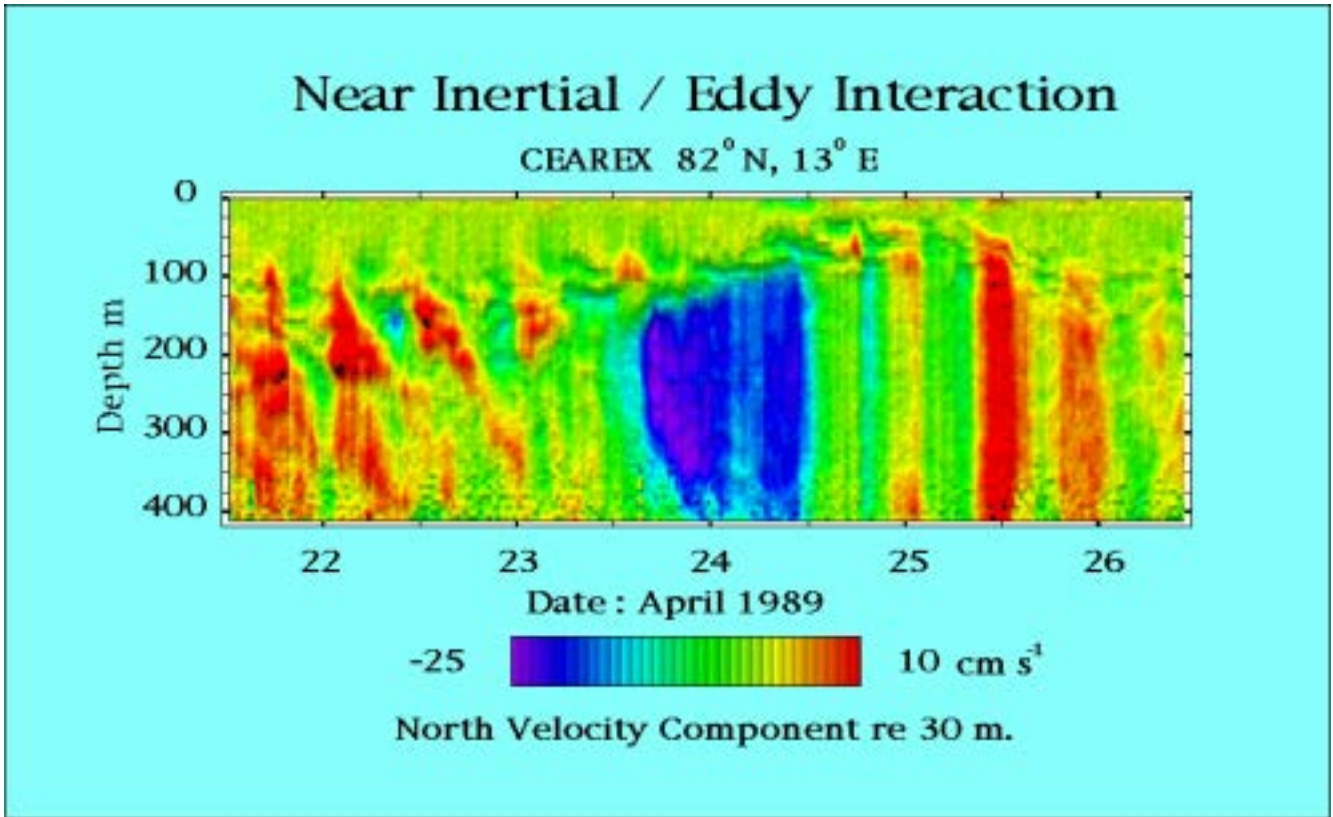


Figure 1. An anticyclonic eddy observed at 82 N in CEAREX. Wave energy accumulates as upward propagating groups transit the positive vorticity region of the outer skirts (days 22, 23 April). Energy buildup is also seen above the central core, as upward propagating waves encounter the quiescent region above the negative vorticity core.

A second surprise in SIMI was that not every storm produced a strong inertial response in the thermocline. Specifically, when arctic eddies were passing under the camp, wave propagation was strongly affected (Figure 1). A typical arctic eddy has a core of radius 5 km that rotates anticyclonically as a solid body. The skirts of the eddy extend from 5-25 km. While the flow is still in a clockwise sense, the decay of velocity with increasing distance from the core leads to a change in sign of the vertical component of vorticity (Figure 2). Spatial variation in this "background vorticity" can be thought of as a local change in the rotation rate of the earth (Kunze, 1985).

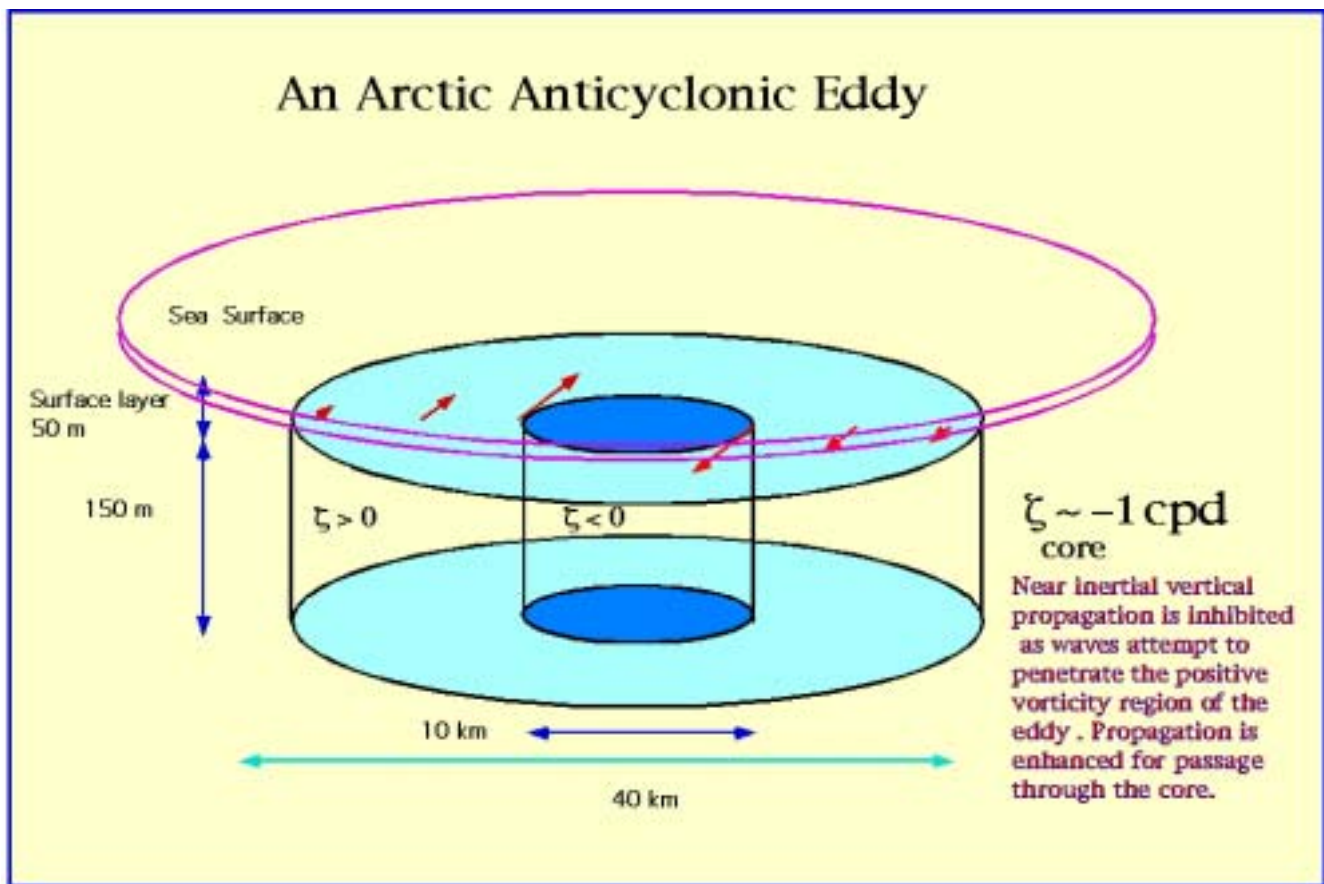


Figure 2. *Schematic of an anticyclonic eddy showing a central core of negative vorticity surrounded by a positive vorticity skirt. Viewed in plan most of the area of a clockwise rotating eddy is associated with positive vorticity.*

Vertical gradients in this rotation rate influence the propagation of near inertial waves significantly. Specifically, wave propagation from above or below the eddy into its interior is inhibited in the positive vorticity skirt-region. Vertical propagation through the negative vorticity core is enhanced, creating the "inertial chimney" effect first described by Lee and Niiler.

IMPACT/APPLICATIONS

These eddies, which comprise 20-40% of the volume of Pacific Layer and related waters in the Central Beaufort Sea, strongly modulate the flow of energy between the sea surface and the warm Atlantic waters which lie ~200 m below. One expects that patterns of vertical mixing are modulated as well and that small scale variations in sound speed are also enhanced in regions of wave build-up.

TRANSITIONS

Work has been submitted to JGR for publication.

RELATED PROJECTS

The SIMI observations are being compared with the subsequent data from the NSF SHEBA experiment. Between the two experiments a coherent picture of the wavefield in the Western Arctic is beginning to emerge.

PUBLICATIONS

Alford, M.H., R. Pinkel, 2000: Observations of overturning in the thermocline: The context of ocean mixing. *J. Phys. Oceanogr.*, 30, 805-832

Alford, M.H., R. Pinkel, 2000: Patterns of Turbulent and Double-Diffusive Phenomena: Observations from a Rapid-Profiling Microconductivity Probe. *J. Phys. Oceanogr.*, 30, 833-854